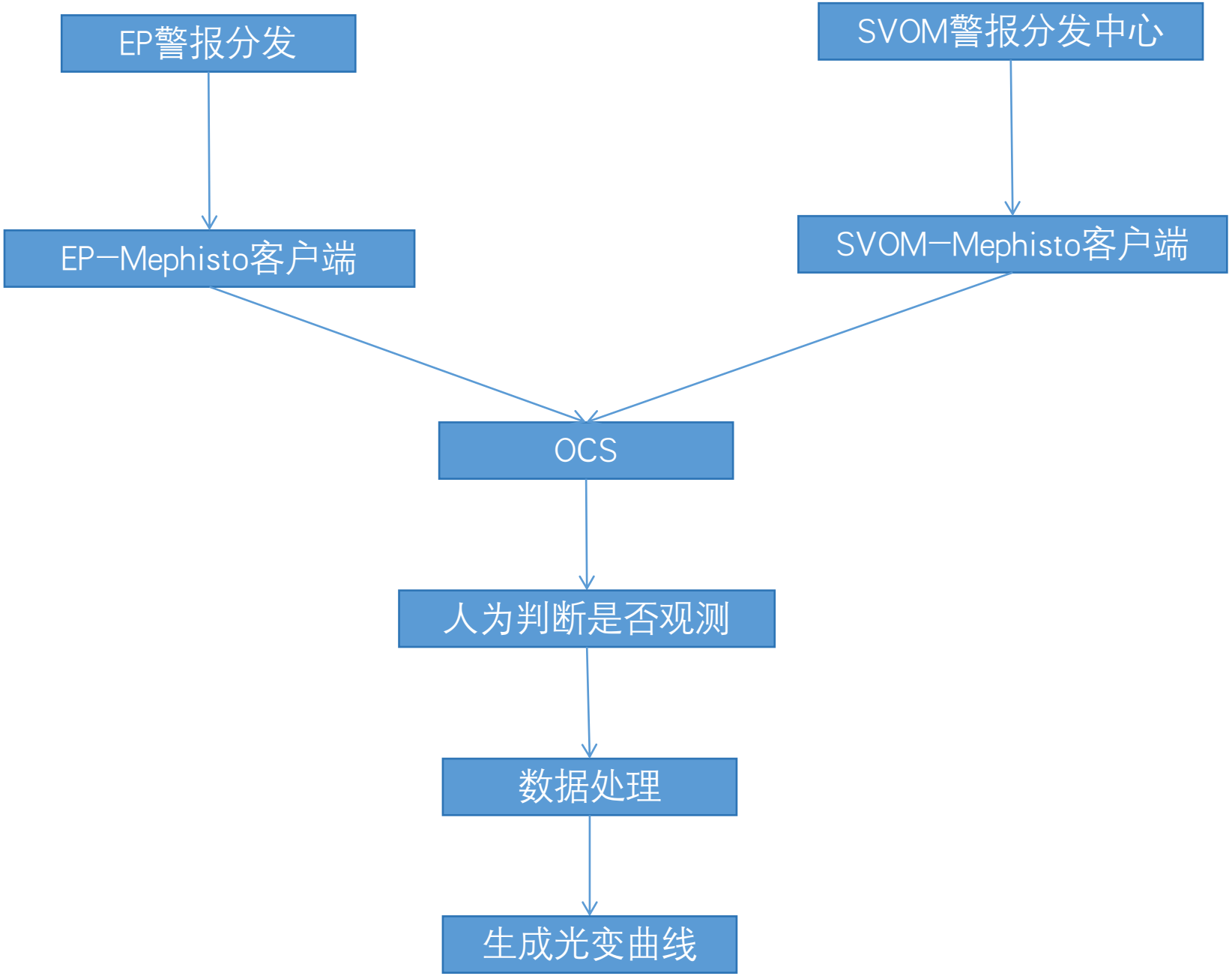
Mephisto望远镜警报后随响应系统

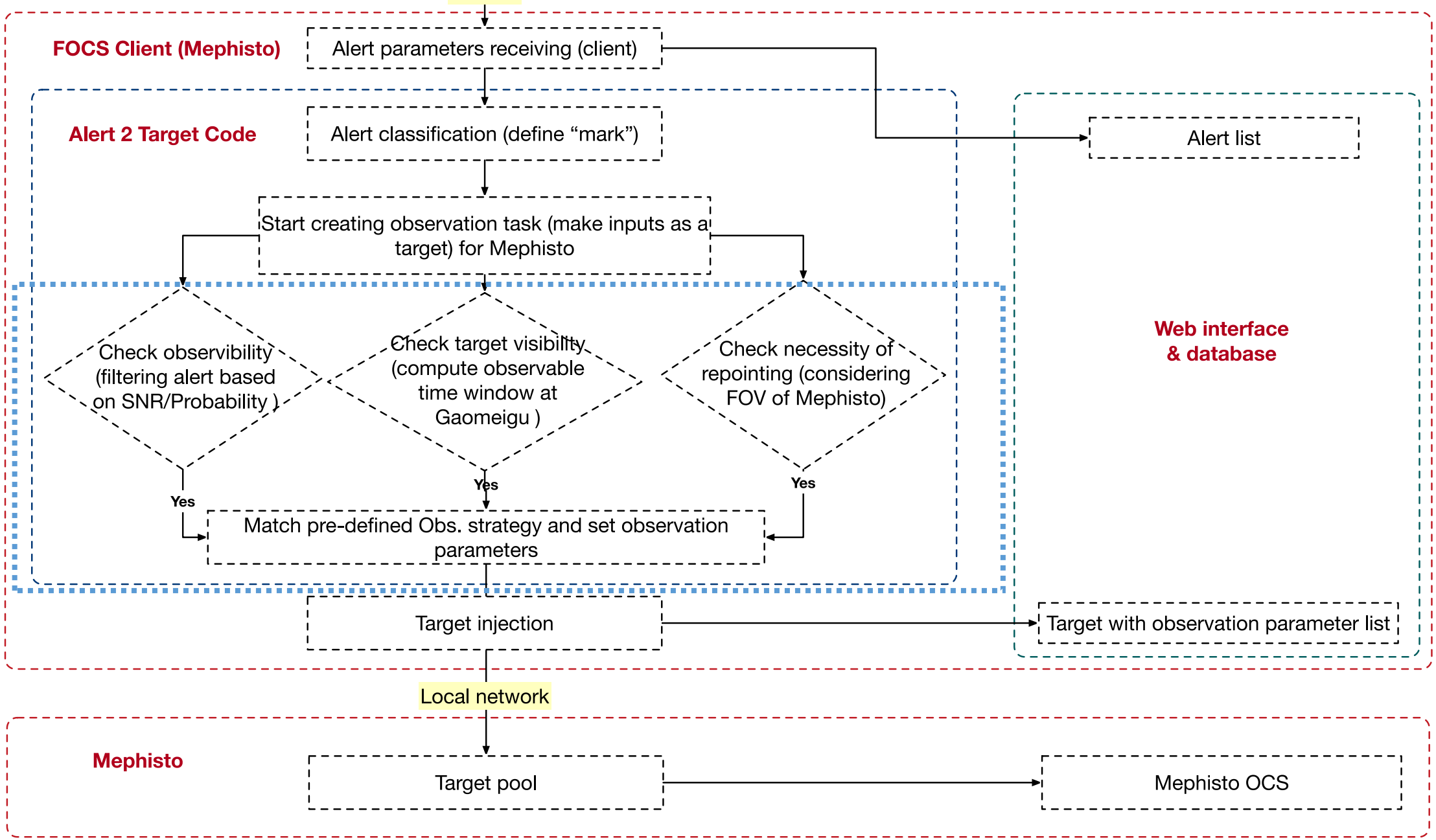
杜国王・云南大学

2025.05.26 北京 @ 天关卫星时代的恒星X射线耀发研讨会

梦飞后随系统警报响应和处理流程



客户端相应流程


FOCS Client (Mephisto)
Alert parameters receiving (client)
Alert 2 Target Code
Alert classification (define “mark”)
Alert list
Start creating observation task (make inputs as a target) for Mephisto
Check observibility (filtering alert based on SNR/Probability)
Check target visibility (compute observable time window at Gaomeigu)
Check necessity of repointing (considering FOV of Mephisto)
Web interface & database
Yes
Yes
Yes
Match pre-defined Obs. strategy and set observation parameters
Target injection
Target with observation parameter list
Local network
Mephisto
Target pool
Mephisto OCS

TRIGGER | TARGET | CONFIGURATION OF ALERT2TARGET

LAY/EXPORT NOTICE | EXPORT LIST

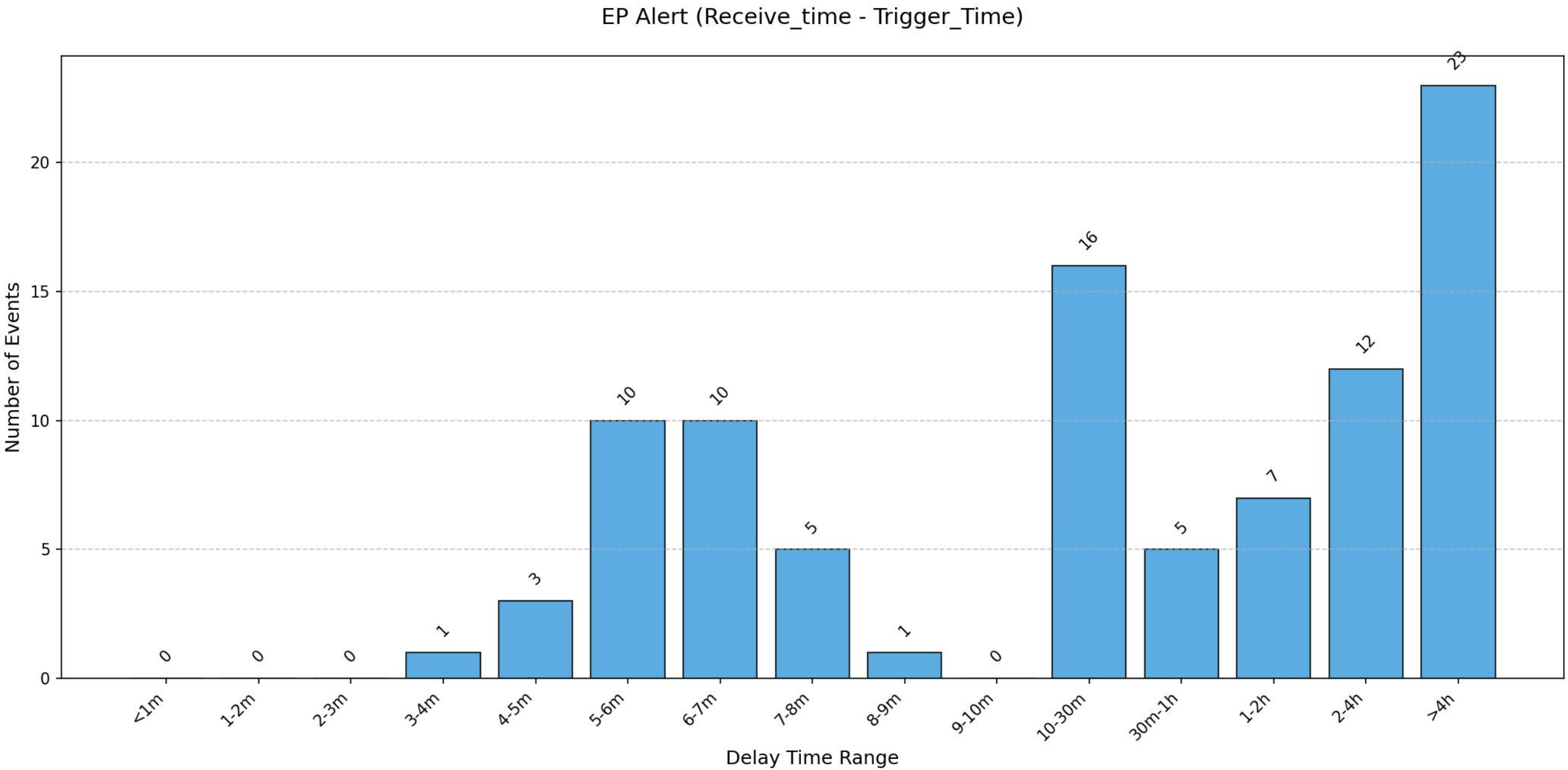
0170

TRIGGER	TYPE	TRIGGER TIME	ALERT TYPE	RA	DEC	ERR	NOTE	SNR	PROBA	LATEST RECV TIME
01709176979	X-ray Transient	2025-05-26 19:28:23.099	EP-891	217.021000 14:28:05.0	-34.310000 -34:18:36	3.163		7.5		2025-05-27 02:32:08.140
01709176712	X-ray Transient	2025-05-23 12:44:31.699	EP-891	213.960000 14:15:50.4	-21.596000 -21:35:46	3.066		7.1		2025-05-23 12:51:17.619
01709176612	X-ray Transient	2025-05-22 05:56:51.199	EP-891	186.249000 12:24:59.8	-52.275000 -52:16:30	3.077		7		2025-05-22 06:03:26.406
01709176312	X-ray Transient	2025-05-16 19:26:03.849	EP-891	17.762000 01:11:02.9	-73.288000 -73:17:17	3.081		7		2025-05-17 03:05:45.559
01709175718	X-ray Transient	2025-05-12 11:22:08.249	EP-891	215.216000 14:20:51.8	-10.092000 -10:05:31	3.031		12.2		2025-05-13 03:18:46.028
01709175648	X-ray Transient	2025-05-11 07:59:59.449	EP-891	202.096000 13:28:23.0	-2.725000 -02:43:30	3.057		9.8		2025-05-13 03:17:58.059
01709175339	X-ray Transient	2025-05-08 06:03:47.999	EP-891	178.266000 11:53:03.8	-19.900000 -19:54:00	3.077		10.7		2025-05-08 06:11:52.715
01709175213	X-ray Transient	2025-05-06 21:07:59.349	EP-891	299.150000 19:56:36.0	3.460000 +03:27:36	3.135		8.6		2025-05-06 21:11:56.033
01709135324	X-ray Transient	2025-04-27 03:38:24.775	EP-891	277.281000 18:29:07.4	7.570000 +07:34:12	2.034		33.251		2025-04-27 07:29:02.056
01709135179	X-ray Transient	2025-04-21 16:16:28.949	EP-891	172.413000 11:29:39.1	-24.683000 -24:40:59	3.048		8.4		2025-04-21 16:21:34.592
01709135021	X-ray Transient	2025-04-16 17:53:59.199	EP-891	256.402000 17:05:36.5	25.768000 +25:46:05	3.052		10.4		2025-04-16 21:09:12.463
01709133918	X-ray Transient	2025-04-04 14:19:59.253	EP-891	125.064000 08:20:15.4	35.511000 +35:30:40	3.050		11.1		2025-04-04 14:24:35.514
01709133860	X-ray Transient	2025-04-02 12:30:32.534	EP-891	172.168000 11:28:40.3	-47.290000 -47:17:24	3.000		6.275		2025-04-03 03:11:07.948
01709133862	X-ray Transient	2025-04-02 17:38:19.603	EP-891	224.635000 14:58:32.4	-39.246000 -39:14:46	3.054		8.2		2025-04-03 00:17:09.543
01709133021	X-ray Transient	2025-03-24 09:38:23.303	EP-891	184.658000 12:18:37.9	39.187000 +39:11:13	3.024		8.1		2025-03-24 13:30:22.342
01709133009	X-ray Transient	2025-03-21 06:09:59.249	EP-891	179.262000 11:57:02.9	17.386000 +17:23:10	3.086		8.3		2025-03-22 14:53:01.117

警报接收界面

TRIGGER | TYPE | (+9 others)

Total: 16 | 1 | Items/Page 20


EP Alert (Receive_time - Trigger_Time)
Number of Events
Delay Time Range
0
5
10
15
20
<1m
1-2m
2-3m
3-4m
4-5m
5-6m
6-7m
7-8m
8-9m
9-10m
10-30m
30m-1h
1-2h
2-4h
>4h
0
0
0
1
3
10
10
5
1
0
16
5
7
12
23

TRIGGER | TARGET | CONFIGURATION OF ALERT2TARGET

posted received running complete broken passed

OBS. STAGE: All

017

ID	MISSION	TRIGGER	TELESCOPE	TARGET NAME	OBS.	RA	DEC	OBS. STAGE	OBS. PARA	BEG TIME	END TIME	GEN TIME
2014	EP	01709176979	Mephisto-50cm	SVOM-FOCS_C-EP-01709176979-34001-0	N	217.021000	-34.310000	AUTOMATIC FOLLOWUP		2025-05-27 13:20:00.000	2025-05-27 17:20:00.000	2025-05-27 02:32:08.650
2013	EP	01709176979	Mephisto	SVOM-FOCS_C-EP-01709176979-34001-1	N	217.021000	-34.310000	AUTOMATIC FOLLOWUP		2025-05-27 14:00:00.000	2025-05-27 17:00:00.000	2025-05-27 02:32:08.451
2012	EP	01709176979	Mephisto	SVOM-FOCS_C-EP-01709176979-34001-0	N	217.021000	-34.310000	AUTOMATIC FOLLOWUP		2025-05-27 14:00:00.000	2025-05-27 17:00:00.000	2025-05-27 02:32:08.422
2008	EP	01709176712	Mephisto-50cm	SVOM-FOCS_C-EP-01709176712-33693-0	N	213.960000	-21.596000	AUTOMATIC FOLLOWUP		2025-05-23 13:00:00.000	2025-05-23 18:40:00.000	2025-05-23 12:51:18.171
2007	EP	01709176712	Mephisto	SVOM-FOCS_C-EP-01709176712-33693-1	N	213.960000	-21.596000	AUTOMATIC FOLLOWUP		2025-05-23 13:00:00.000	2025-05-23 18:20:00.000	2025-05-23 12:51:17.973
2006	EP	01709176712	Mephisto	SVOM-FOCS_C-EP-01709176712-33693-0	N	213.960000	-21.596000	AUTOMATIC FOLLOWUP		2025-05-23 13:00:00.000	2025-05-23 18:20:00.000	2025-05-23 12:51:17.950
1987	EP	01709175718	Mephisto-50cm	SVOM-FOCS_C-EP-01709175718-32699-0	N	215.216000	-10.092000	AUTOMATIC FOLLOWUP		2025-05-13 13:00:00.000	2025-05-13 20:00:00.000	2025-05-13 03:18:46.541
1986	EP	01709175718	Mephisto	SVOM-FOCS_C-EP-01709175718-32699-1	N	215.216000	-10.092000	AUTOMATIC FOLLOWUP		2025-05-13 13:00:00.000	2025-05-13 19:40:00.000	2025-05-13 03:18:46.325

天文警报系统

TRIGGER | TARGET | CONFIGURATION OF ALERT2TARGET

SET TELESCOPE

OBSERVATORY

SET OBSERVATORY LOCATION

OBSERVATORY1: Gaomeigu

TELESCOPES

EDIT TELESCOPE LIST

TELESCOPE1: Mephisto

TELESCOPE2: Mephisto-50cm

SELECT TELESCOPE

Gaomeigu

MEPHISTO | MEPHISTO-50CM

ALERT2TARGET SWITCH FOR SELECTED TELESCOPE

SELECTED NOTICE TYPE AND THRESHOLD (indicates setting of thresholds)

MANAGE NOTICE

Swift-61 | Swift-67 | SVOM-200 | SVOM-202 | SVOM-204 | SVOM-206 | SVOM-208 | SVOM-209 | SVOM-210 | EP-890 | EP-891

SWITCH

TURN ON OR OFF FOR FILTERS

VISIBILITY

REPOINTING

SAVE

VISIBILITY

DEFINE POINTING BOUNDAR

MINZENITH OF SUN 100

MAXZENITH OF TARGET 65

SAVE

REPOINTING

DEFINE REPOINTING DISTANCE

DISTANCE (ARCMIN.) 15

SAVE

天文警报过滤

- 每个卫星在探测到不同阶段会发送不同类型编码的警报，比如SVOM有11种警报。我们可根据对于错误警报的容忍度设置订阅不同阶段的警报。在该系统中，Mephisto主要订阅SVOM的警报类型为200、202、204、206、208、209和210。
- SVOM的199警报类型较早，但是大部分情况下，没有坐标或者较为不准，因为并未进行订阅。
- Fermi也会发送警报，但是由于其误差范围通常非常大，因此我们只是接收，不进行警报。

MISSION: SVOM

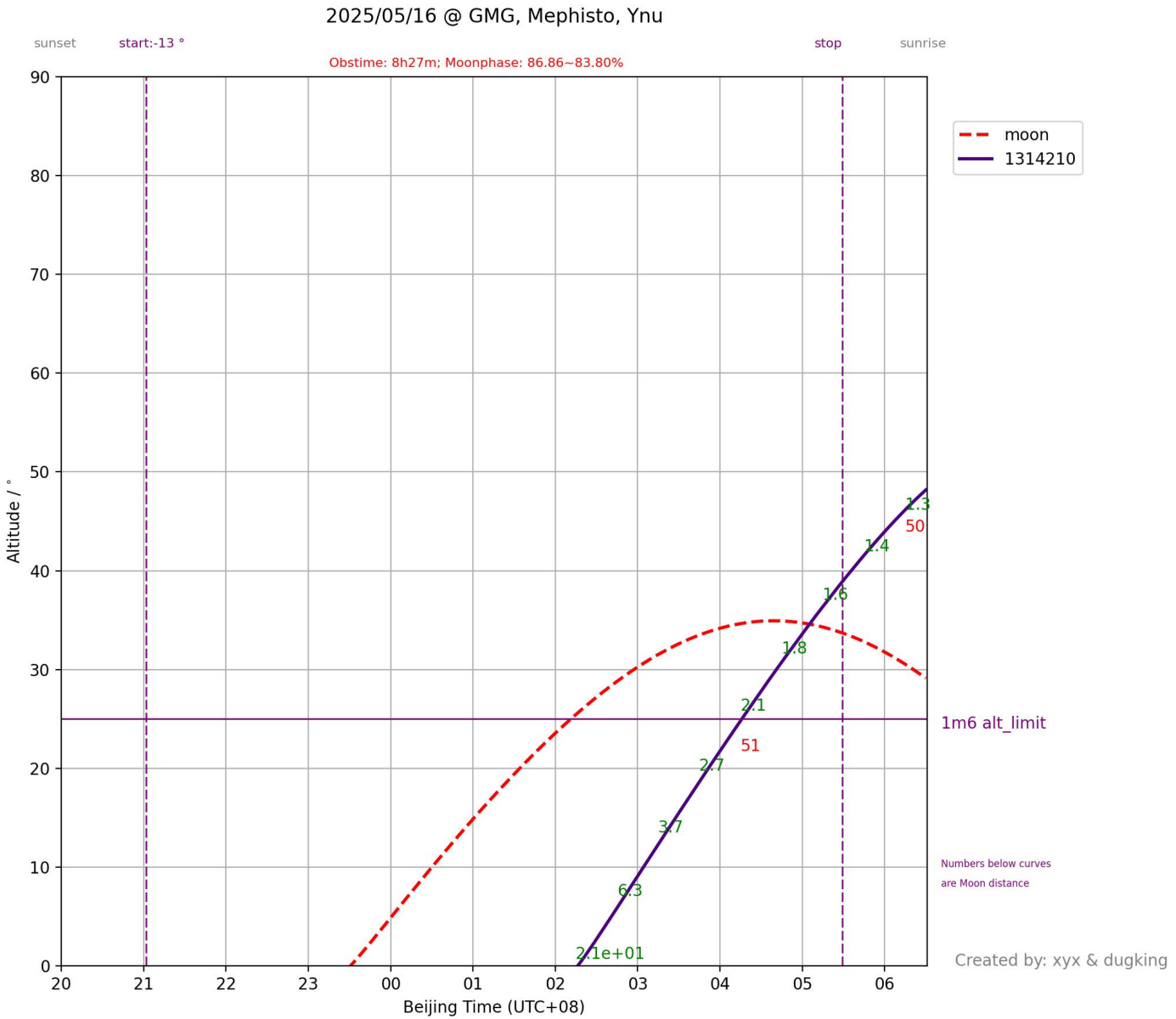
NOTICE TYPE	DESCRIPTION
SVOM-199	The Svom-GRM-preliminary N1g notice
SVOM-200	The Svom-Eclairs-preliminary N1e notice
SVOM-201	The Svom-GRM N1g notice
SVOM-202	The Svom-Eclairs-wakeup N1e notice
SVOM-203	The Svom-Eclairs-catalog N1e notice
SVOM-204	The Svom slewing N1e notice
SVOM-205	The Svom not-slewing N1e notice
SVOM-206	The Svom-Eclairs-refined N2e notice
SVOM-207	The Svom-GRM-refined N2g notice
SVOM-208	The Svom-Eclairs-GRM joint N2j notice

MISSION: EP

NOTICE TYPE	DESCRIPTION
EP-890	The EP/WXT on board notice
EP-891	The EP/WXT ground notice

客户端响应逻辑与任务判断

- 目标可观测性检查
  - 后台自动根据丽江天文观测站的经纬度和Mephisto望远镜的观测高度限制(粗略设置限制为25)，自动判断警报在夜晚观测时间范围内是否可以观测。



观测计划生成

- 系统采用的三通道曝光方案为：蓝（u/g）通道45秒、黄（v/r）通道45秒、红（i/z）通道45秒。

DEFINE OBSERVATION STRATEGY FOR SELECTED TELESCOPE

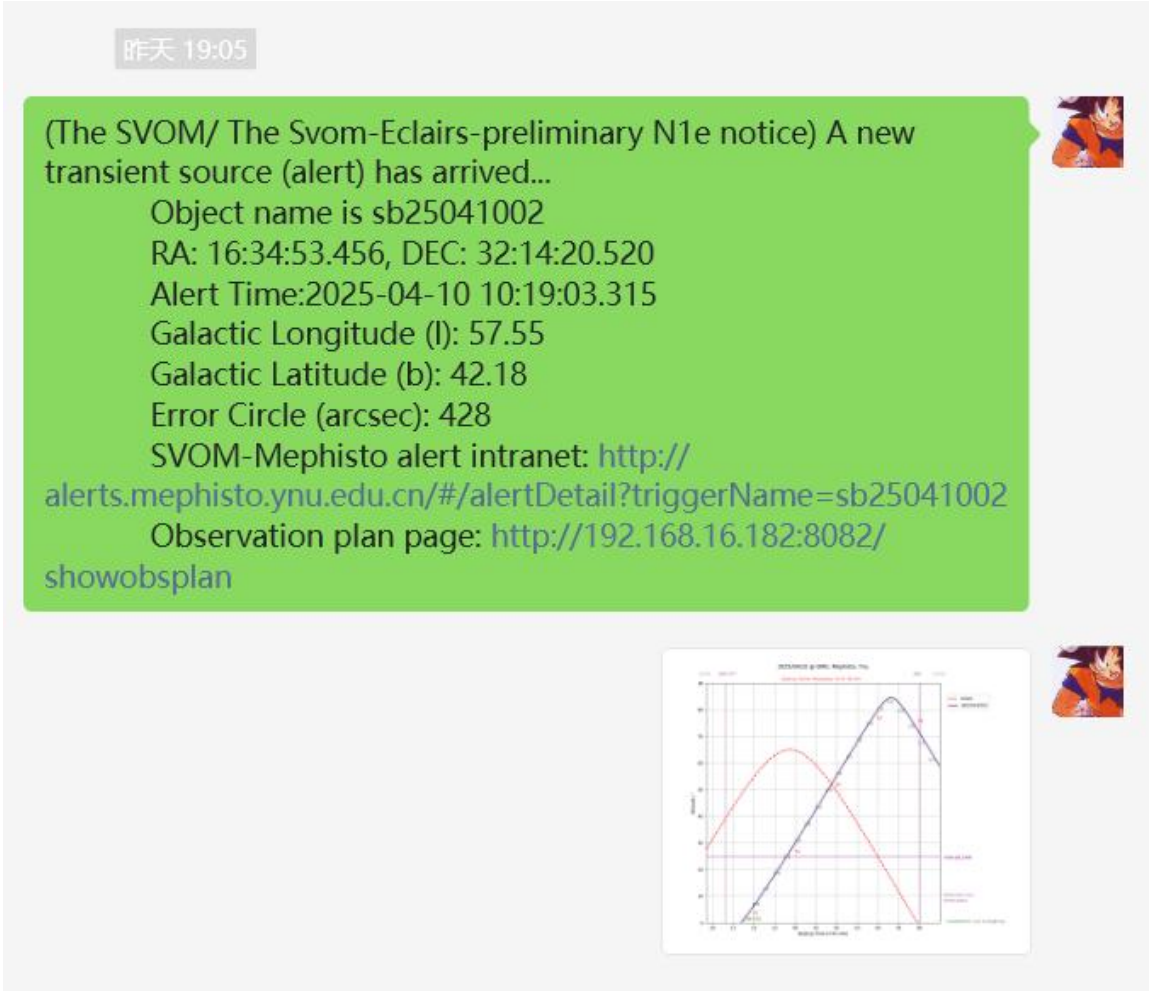
+ ADD

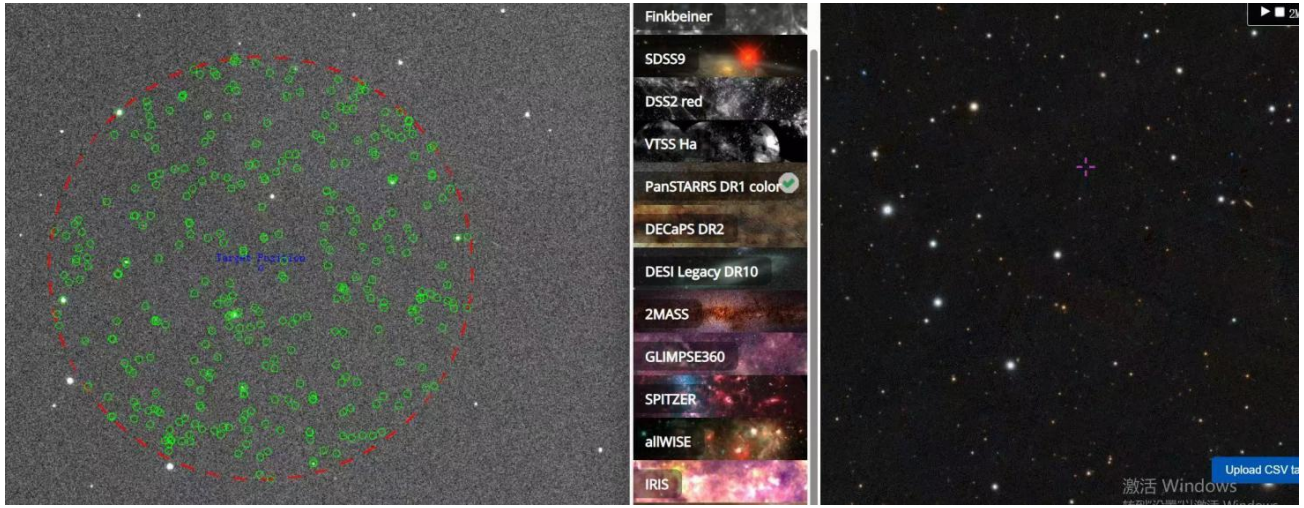
MANAGE EXPOSURE PARAMETERS

ID	TELESCOPE	STRATEGY	NOTICE TYPE	FILTER	EXPTIME	DELAY	FRMCNT	LOOPCNT	READMODE	PRIORITY	ACTION
38	Mephisto	X2	Swift-61, Swift-67, SVOM-202, SVOM-204, SVOM-206, SVOM-208, SVOM-209, SVOM-210, EP-890, EP-891, SVOM-200	v|r|z	45|45|45	0|0|0	1|1|1	6	normal	67	
37	Mephisto	X1	Swift-61, Swift-67, SVOM-202, SVOM-204, SVOM-206, SVOM-208, SVOM-209, SVOM-210, EP-890, EP-891, SVOM-200	u|g|i	45|45|45	0|0|0	1|1|1	6	normal	67	

观测任务的推送

- 观测任务生成后，观测计划会被推送至观测室OCS观测数据库，并触发现场语音提示告知值班人员新暂现源到达，同时微信机器人向Mephisto望远镜值班微信群自动发送源名称、天球坐标、银经银纬及定位精度等关键信息。





- OCS观测计划后台利用Panstarr星表进行**自动生成辅助认证的region**。值班人员确认**天气条件允许**后，可中断或排队当前观测任务以执行新观测；若发生在夜间，则由观测人员自主决策是否打断既有观测流程。

数据自动化采集处理

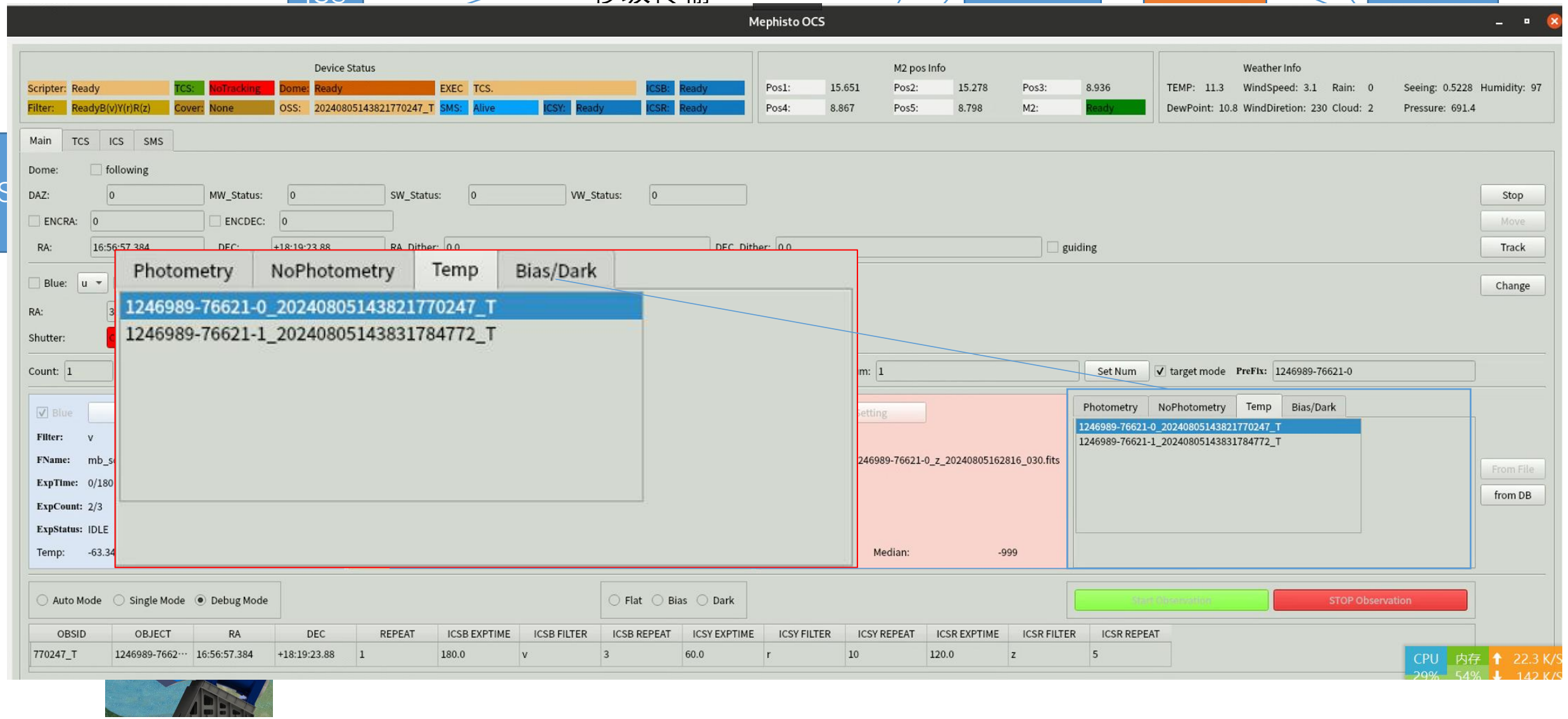
alerts

ICS

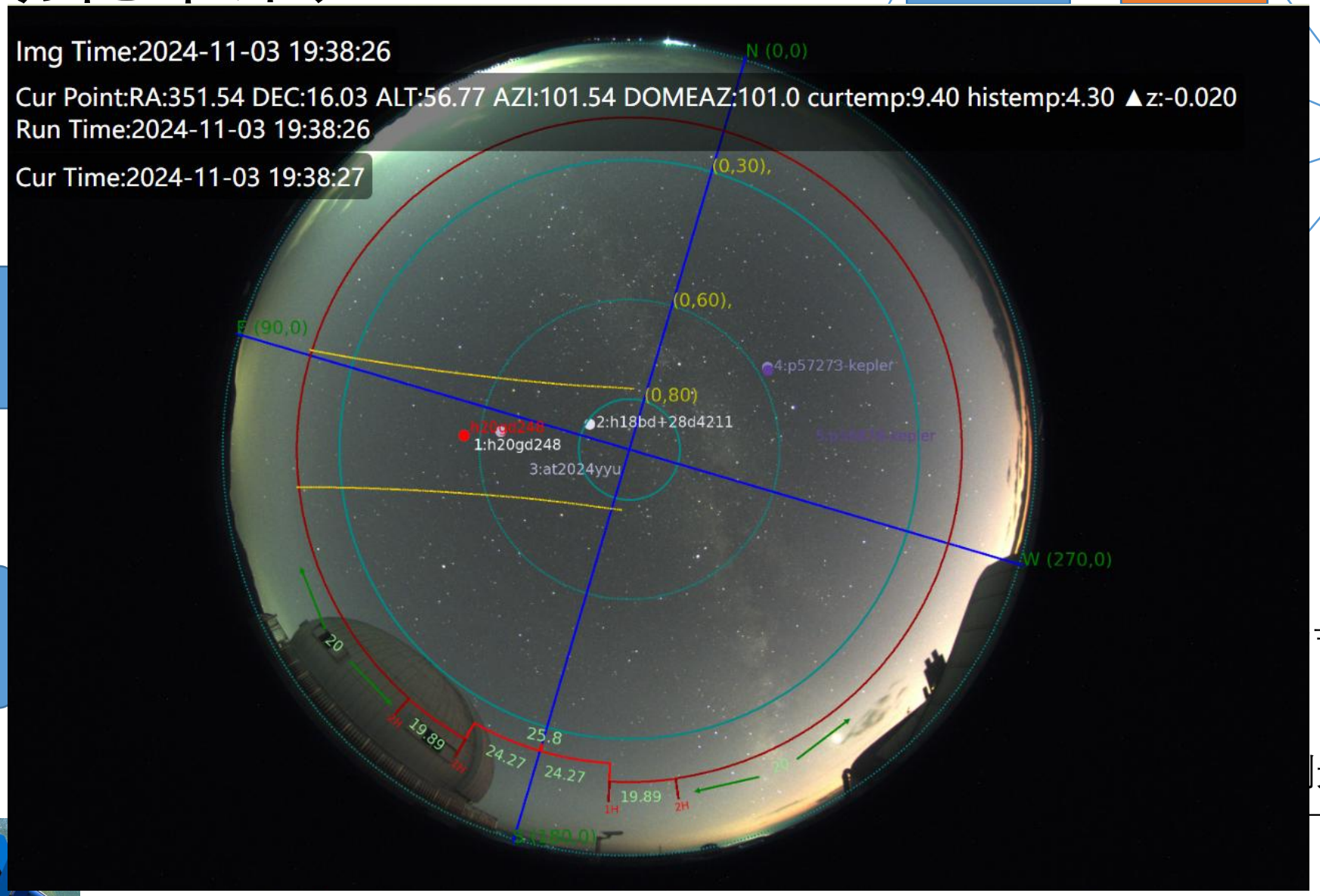
40GB光纤，
秒级传输

服务器1 → 本地存储

服务器2 → 本地存储



数据自动化采集处理



alerts

SMS

OCS

TCS

服务器1

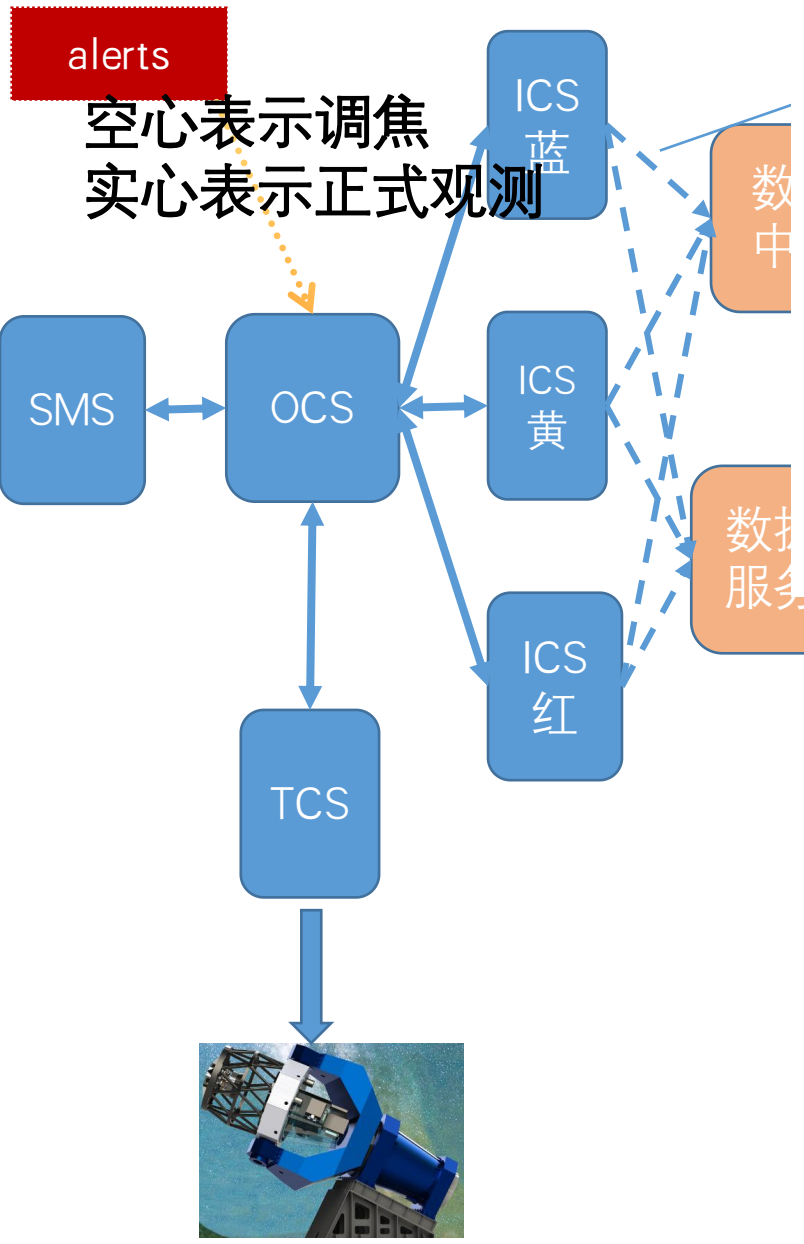
本地存储

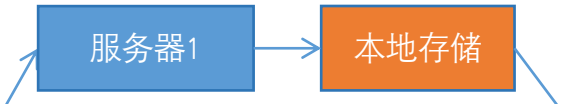
LC DB

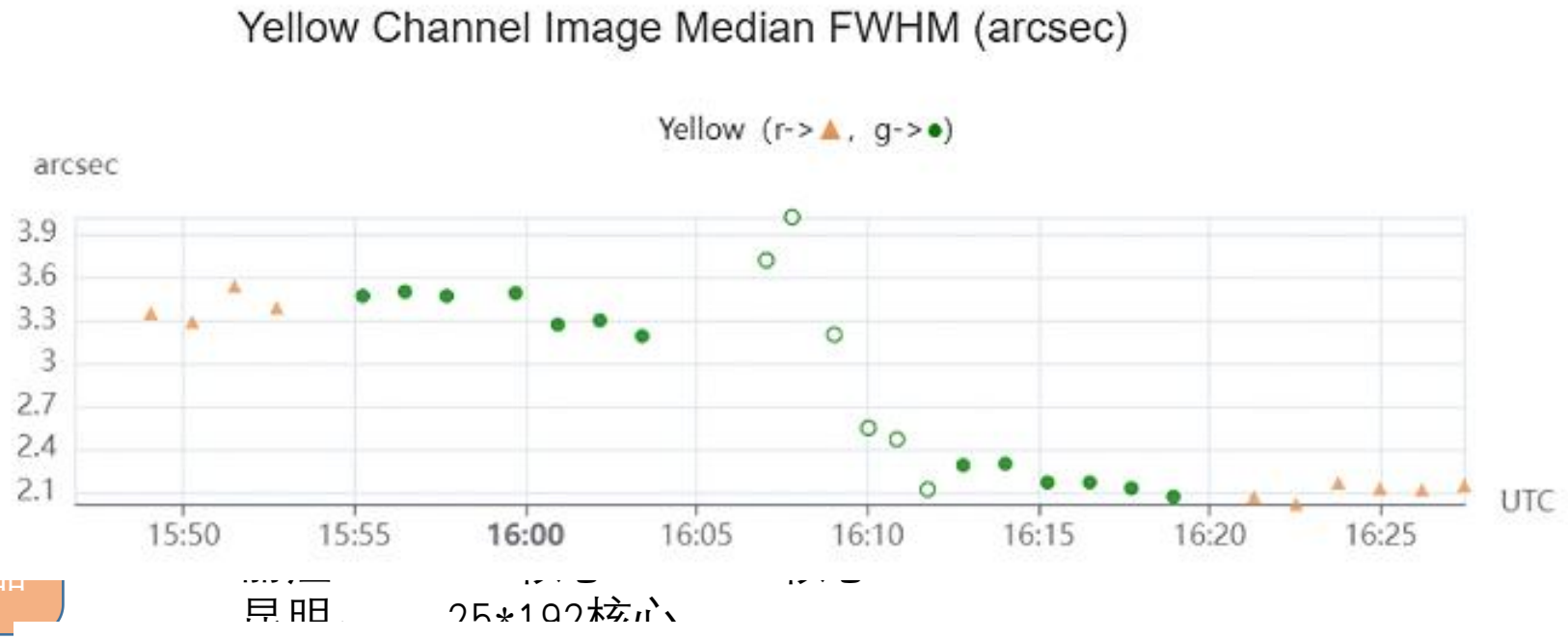
节点进行处理。

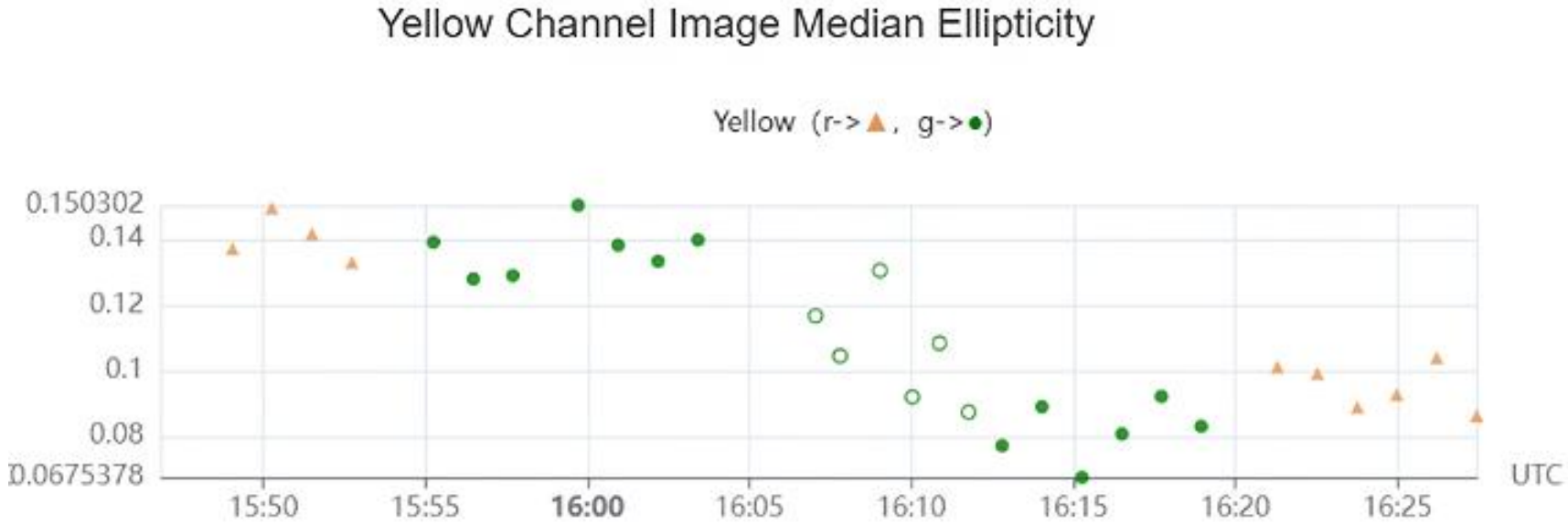
光，如红通道
—5分钟处理完

数据自动化采集处理

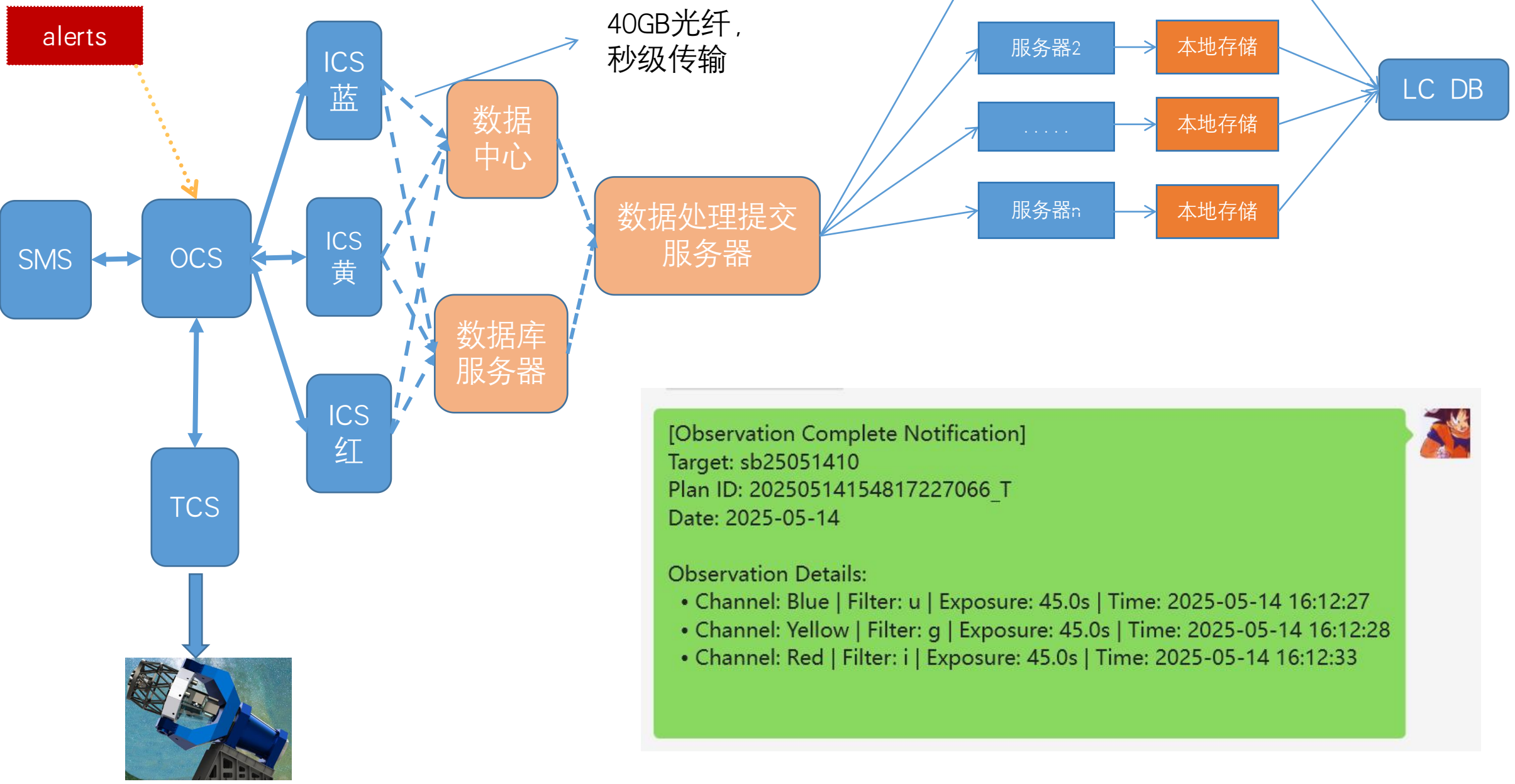

alerts
空心表示调焦
实心表示正式观测
ICS
蓝
数
中
SMS
OCS
ICS
黄
数据
服务器
ICS
红
TCS


服务器1
本地存储


Yellow Channel Image Median FWHM (arcsec)
Yellow (r->▲, g->●)
arcsec
3.9
3.6
3.3
3
2.7
2.4
2.1
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
UTC


Yellow Channel Image Median Ellipticity
Yellow (r->▲, g->●)
0.150302
0.14
0.12
0.1
0.08
0.0675378
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
UTC

数据自动化采集处理



[Observation Complete Notification]
Target: sb25051410
Plan ID: 20250514154817227066_T
Date: 2025-05-14

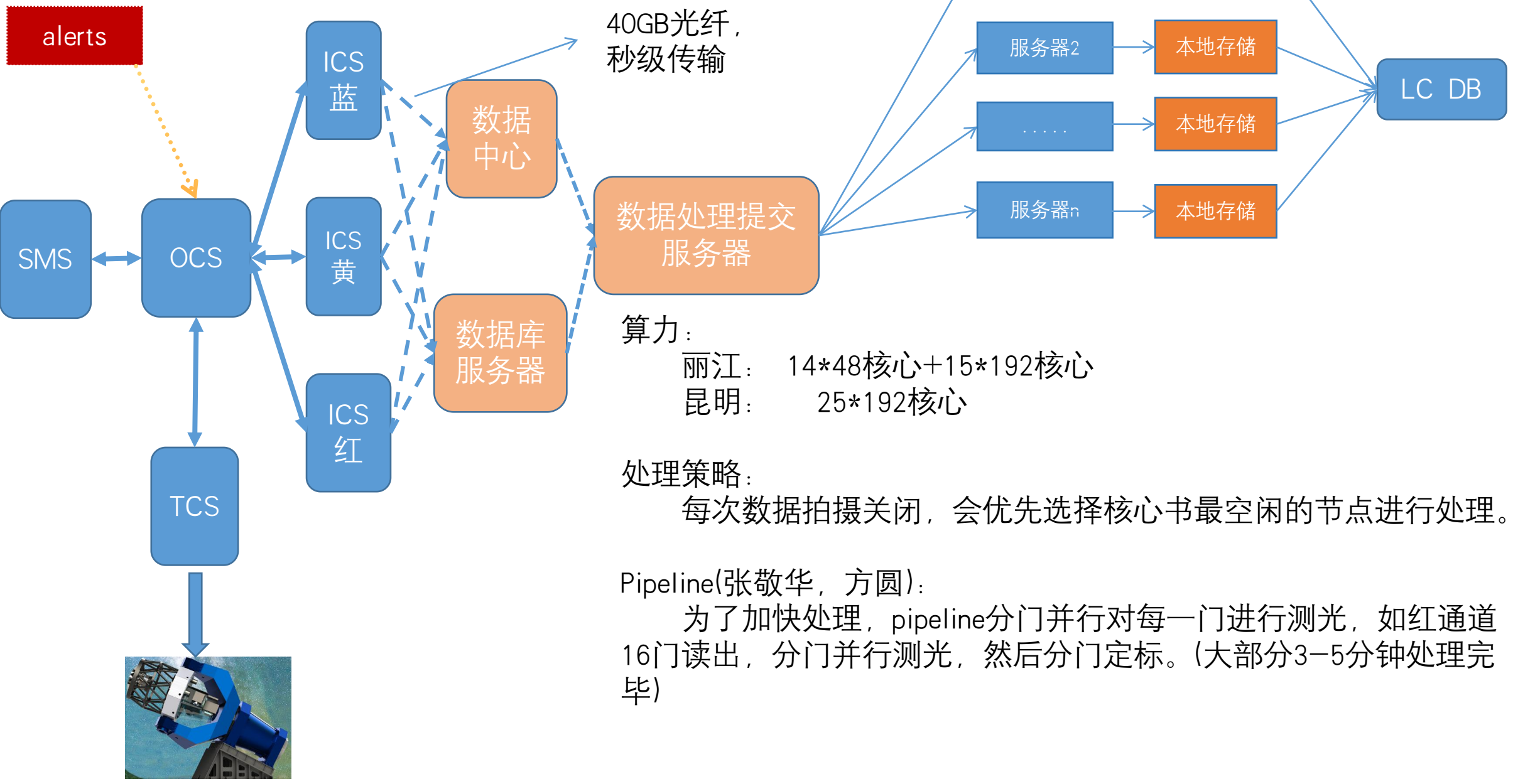
Observation Details:
- Channel: Blue | Filter: u | Exposure: 45.0s | Time: 2025-05-14 16:12:27
- Channel: Yellow | Filter: g | Exposure: 45.0s | Time: 2025-05-14 16:12:28
- Channel: Red | Filter: i | Exposure: 45.0s | Time: 2025-05-14 16:12:33

数据自动化受集理

- 观测数据处理情况 (基本上每幅图4~6分钟之内处理完毕)

Field/Target	FWHM(arcsec) (>2.15:,2.15>=FWHM>1.72:)	FWHM	Ell	Preview	Data Products	Astrometric fit residual	Astrometry vs 2Mass	Astrometry vs PanSTARRS	SNR vs MAG	Err vs MAG	GAIA_MAG vs MAG	Camero
1246989-76621-0		2.03	0.1									Y
1246989-76621-0		2.102	0.12									Y
1246989-76621-0		1.567	0.09									R
1246989-76621-0		2.039	0.11									Y
1246989-76621-0		2.17	0.08									B
1246989-76621-0		2.14	0.1									Y
1246989-76621-0		1.519	0.09									R
1246989-76621-0		1.98	0.11									Y
1246989-76621-0		2.09	0.09									B
1246989-76621-0		1.441	0.09									R

数据自动化采集处理



算力：

丽江：　14*48核心+15*192核心

昆明：　25*192核心

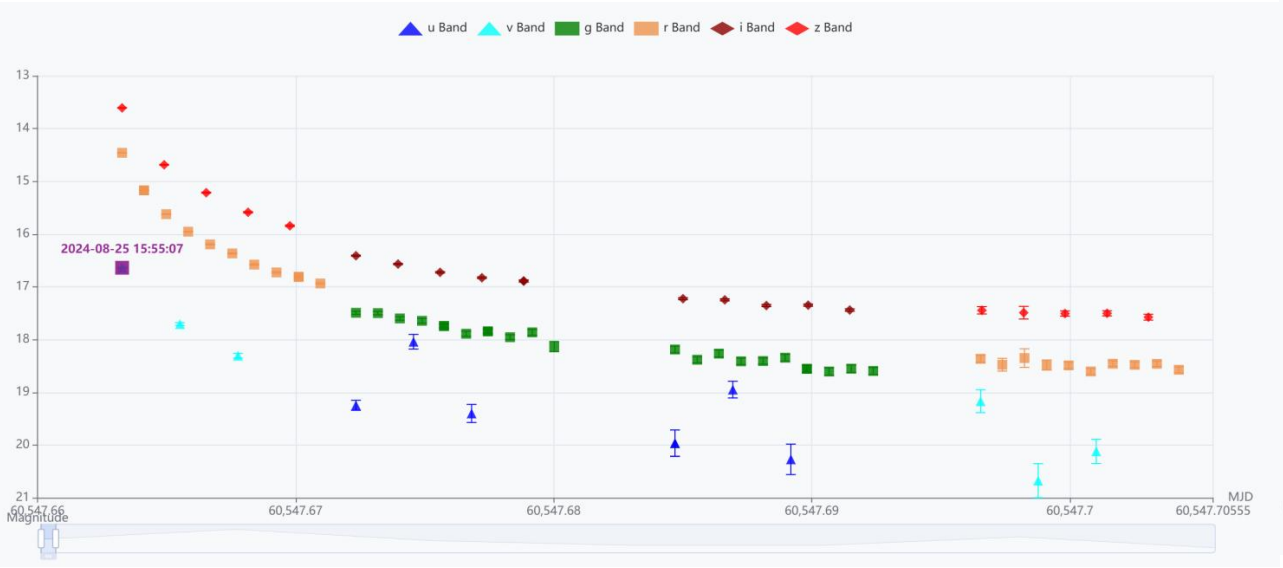
处理策略：

每次数据拍摄关闭，会优先选择核心书最空闲的节点进行处理。

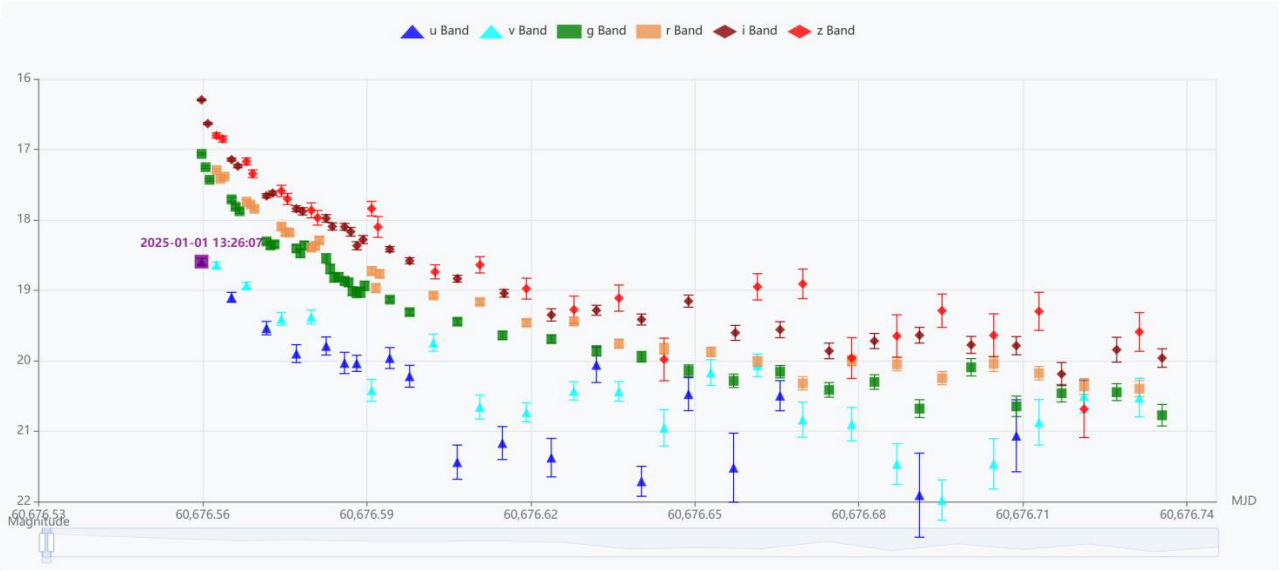
Pipeline(张敬华，方圆)：

为了加快处理，pipeline分门并行对每一门进行测光，如红通道16门读出，分门并行测光，然后分门定标。(大部分3-5分钟处理完毕)

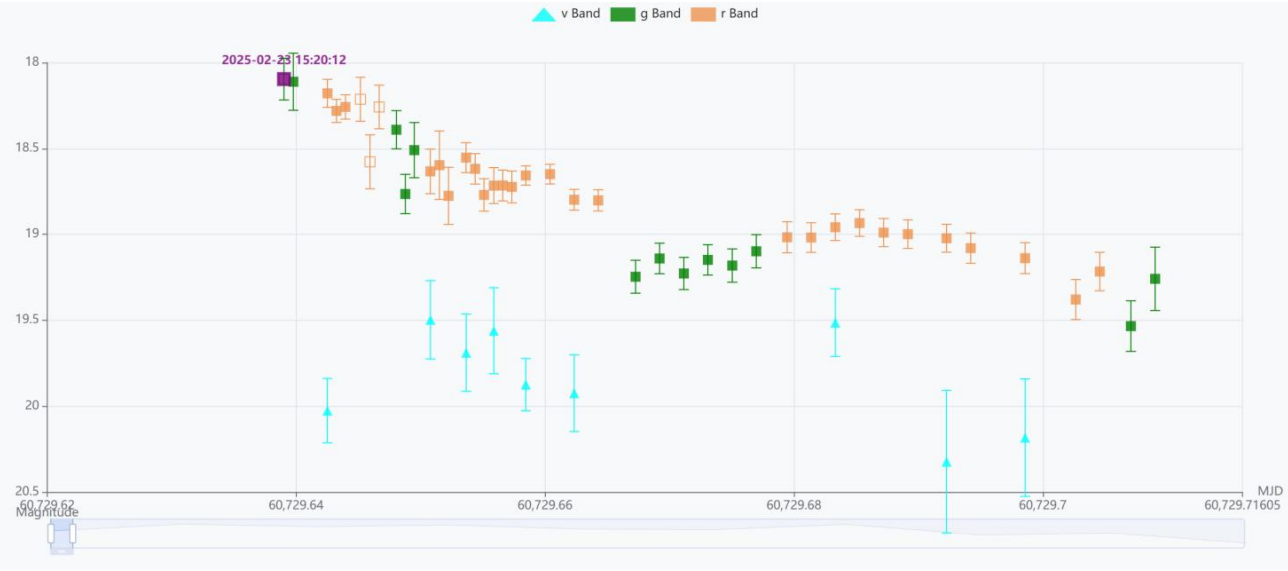
光变曲线示例



GRB240825A



GRB 250101A



GRB 250223A

EP 250404A

EP发布的Alert，梦飞观测情况(共收到30次，23次进行了后随)

No.	burst	trigger	detected (yes/no)	t-T0	Paper
E01	EP trigger ID 01709122294：1.6m Mephisto multi-band optical observations	EP	yes	18.65hr	
E02	EP240904a （观测但是未发布GCN）	EP	no	3.2 days	与EP合作
E03	EP240913a/GRB 240913C：1.6m Mephisto observations	EP	yes	26.9hr	
E04	EP240918a：1.6m Mephisto multi-band Optical Upper Limit	EP	no	2.33hr	
E05	EP241021a：Optical rebrightening observations with Mephisto	EP	yes	8.42 day	
E06	EP 241113A （观测但是未发布GCN）	EP	no		与EP合作
E07	EP241126a：1.6m Mephisto Optical Upper Limits	EP	no	15.8hr	
E08	EP241201a：1.6m Mephisto Optical Upper Limits	EP	no	2.5 day	
E09	EP241217a：1.6m Mephisto multi-band optical observations	EP	yes	8.53 hr	
E10	GRB 241217a/EP241217B：1.6m Mephisto optical upper limits	EP+SVOM	no	~12 min	
E11	**EP250108a：Mephisto detection**	EP	yes	0.97 day	与EP合作
E12	GRB 250109A / EP250109a：Mephisto optical upper limits	EP+Fermi	no	6.15hr	
E13	EP250109b(观测了但是未发送GCN)	EP	no		
E14	GRB 250215A/EP250215a：1.6m Mephisto optical observation report	Fermi+EP	yes	14hr	
E15	EP250220a：1.6m Mephisto observations				
E16	**EP250223a：1.6m Mephisto and 50cm array observations**	EP	yes	15.6 min	与EP合作
E17	EP250226a/GRB 250226A：1.6m Mephisto observations	EP	yes	11.5hr	
E18	EP250308a：1.6m Mephisto optical upper limits	EP	yes	11.5hr	
E19	Mephisto optical upper limit of EP250321b	EP	no	27hr	
E20	**EP250404a：Mephisto multi-band optical detection**	EP	Yes	723s	与EP合作
E21	EP250421a：Mephisto optical counterpart confirmation	EP	yes	~5 mins	
E22	EP250511a：Mephisto optical upper limits	EP	Yes	~6 hr	
E23	**ttauri(观测到恒星耀发)**	EP	Yes		

Star	FXT obs time	RA	Dec
LP 820-19	240714	336.5048158	-15.30362227
ASAS J211056+3323.2	240727	317.7339959	33.38694821
UCAC4 334-220322	240730	356.8436271	-23.28813825
RX J0123.4+1638	240818	20.85592907	16.6440159
TYC 614-313-1	240829	22.81275053	8.589585607
CRTS J225211.7+095626	240921	343.0487618	9.940832579
2MASS J18351416+2435115	240924	278.8090286	24.58650676
PM J23221-0301	240927	350.5453757	-3.028328571
2MASS J23301129-0237227	241001	352.5470994	-2.622992023
1RXS J225817.2-110434	241005	344.5684919	-11.07140859
Gaia DR3 2534635509050352256	241109	18.38042535	-0.007459321
V644 Tau	241111	56.78059817	23.22635869
BPS CS 31060-0015	241116	3.991973182	-16.61600853
HG 7-33	241116	58.72176406	16.31562185
V410 Tau	241120	64.62961721	28.45448777
ATO J079.4052-07.5576	241215	79.4052139	-7.557689039
RX J0413.4-0139	241215	63.36097	-1.6558809
UCAC4 797-019583	241216	151.8238163	69.34601828
TYC 5360-423-1	241223	88.83356125	-14.37907233
V830 Tau	241227	68.2917919	24.56201541
1RXS J060224.9-163451	250105	90.60235903	-16.58039117
RX J0448.7+1003	250129	72.19742408	10.05076111
RX J0916.1+0153/PM J09161+0153	250202	139.042422	1.885786394
G 118-68	250206	158.3069021	34.15331135
RX J0523.0-0850	250217	80.73774651	-8.836678088
LP 378-313	250302	195.9208153	24.23387755
TYC 2497-986-1	250306	143.6267876	33.56967731
LP 368-98/LP 368-99	250316	133.1868297	22.51557607
LP 323-169	250516	203.1628862	30.98516109
Gaia DR3 6277472183485764992	250523	213.9422394	-21.58397449

EP 44个在线发现的恒星耀发

DEC>−30，剩余30个

红色的表示alert发送给梦飞的(21个)，黑色表示未发送。

trigger_name	trigger_ra	trigger_	trigger_	trigger_time	
EP20240714T171256	336.513	-15.302	EP	2024/7/14 17:12:57	天气不好
EP20240924T102931	278.793	24.596	EP	2024/9/24 10:29:31	白天发送
EP20240927T010348	350.55	-3.02	EP	2024/9/27 1:03:48	白天发送
EP20241001T190008	352.554	-2.622	EP	2024/10/1 19:00:09	天气不好
EP20241005T054354	344.575	-11.062	EP	2024/10/5 5:43:54	白天发送
EP20241109T060155	18.385	-0.001	EP	2024/11/9 6:01:56	白天发送
EP20241116T074257	4.023	-16.604	EP	2024/11/16 7:42:58	白天发送
EP20241120T181001	64.624	28.429	EP	2024/11/20 18:10:01	高度角不合适
EP20241215T084305	63.363	-1.648	EP	2024/12/15 8:43:06	白天发送
EP20241215T202350	79.442	-7.545	EP	2024/12/15 20:23:51	
EP20241216T094445	151.839	69.35	EP	2024/12/16 9:44:45	白天发送
EP20241223T092235	88.836	-14.381	EP	2024/12/23 9:22:36	白天发送
EP20250105T205330	90.609	-16.579	EP	2025/1/5 20:53:30	高度角不适合
EP20250129T044922	72.216	10.03	EP	2025/1/29 4:49:23	高度角不适合
EP20250202T213352	139.021	1.89	EP	2025/2/2 21:33:52	高度角不适合
EP20250206T232412	158.298	34.176	EP	2025/2/6 23:24:13	时间不合适
EP20250217T065623	80.748	-8.833	EP	2025/2/17 6:56:23	白天发送
EP20250302T013756	195.931	24.235	EP	2025/3/2 1:37:57	白天发送
EP20250306T090417	143.643	33.549	EP	2025/3/6 9:04:18	高度角不适合
EP20250316T073048	133.216	22.504	EP	2025/3/16 7:30:48	白天发送
01709176712	213.96	-21.596	EP	2025/5/23 12:44:32	天气不好

21个发送的恒星耀发中，黄色底的表示白天发送。


Thank You!